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Assessing paddy farming sustainability in the Northern Terengganu Integrated Agricultural Development Area (IADA KETARA): A structural equation modelling approach

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ABSTRACT

Production instability and uneconomic sizes of planted areas are amongst the main issues and concerns for sustainability in Malaysian paddy farming. However, a sustainable development approach in the agricultural sector is not solely determined by such factors. Therefore, this study aims to analyse the level of sustainability in paddy farming based on five aspects that cover economic, social, ecology, institutional and technology indicators. The respondents consisted of 350 farmers who are members of the Water Consumer Group of the Northern Terengganu Integrated Agricultural Development Area (IADA KETARA). Based on questionnaires from structured interviews, the data were analysed using structural equation modelling. The results indicate that technological advancement is the primary positive factor that determined the level of sustainability in IADA KETARA. The economy, society and institutions were also positive factors. Thus, it can be concluded that technological advancement is the most crucial element for achieving sustainability in the Malaysian paddy sector. Nevertheless, the adverse ecological impacts that could result from the adoption of any technological advancements must not be underestimated by the stakeholders.

1. Introduction

Data from the World Bank shows that Malaysian carbon dioxide (CO_2) per capita increased from 3.1 tonnes in 1990 to 7.9 tonnes in the year 2011. With the change of the Malaysian economic structure moving towards rapid development in the manufacturing, trade and services sectors, particularly since the 1980s, these sectors are typically criticized. However, prior to that, the successes of the Green Revolution in the early 1970s in revitalizing the agricultural sector were also not implemented in an environmentally friendly manner. The Green Revolution in the Malaysian paddy sector was intensively supported by fossil energy for fertilizers, pesticides, irrigation and other technologies that were suited to the special circumstances. The technological advancement has polluted groundwater and surface water, eroded soil and increased the usage of pesticide, causing a deleterious impact on the environment.

A study by the World Bank claimed that the Malaysian paddy industry is not only unsustainable but also unprofitable (Siwar, 1995). Therefore, Malaysia is continuously committed to practicing a sustainable approach in agriculture to find a balance between the needs of development and the environment (Tawang, 1998). The country's commitment has also been shown by the signing of multiple agreements related to sustainable development, such as the Langkawi Declaration and Convention on Biological Diversity. The introduction of the Integrated Agricultural Project (IADA) since the Third Malaysian Plan (1976–1980) also marked the government's aim to deploy a sustainable development approach in the agricultural sector, particularly the paddy sector. The project has focused on the designation of eight main granary areas involving a host of centralized and coordinated governmental agencies. The authorities are dedicated and mandated to assist in providing capital, machinery, technology, marketing, and

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management assistance as well as infrastructure for sustainable and modern agriculture practices. However, the execution and adoption of sustainable agricultural development still need to be improved. Based on an international benchmarking of a national environmental stewardship called the 2014 Environmental Performance Index, the ecosystem vitality of the Malaysian agricultural sector placed 124th among 178 countries surveyed (Firdaus, 2015). As such, the sustainability of the local rice production is an issue in finding a balance between development and nature.

Most of the main issues of sustainability are usually highlighted in production instability and size of the paddy farms as well as their profitability. Although the ultimate aim of the Integrated Agricultural Development Area (IADA) programme is in line with the concept of sustainable development, these projects lack a focus on environmental and ecological conservation (Mustapha, 1995). Among the paddy areas that have become the IADA is part of the state project located in Northern Terengganu (IADA KETARA), which is the largest paddy production area, accounting for 67 percent for the state of Terengganu (Department of Agriculture, 2014). The main objective of this study is to assess the success of this project in adopting sustainable development practices. This assessment involves five factors, including the economy, society, ecology, technology and institutions based on a structural equation modelling approach.

2. Literature review

The knowledge, technique, models and theories of sustainable agriculture remain elusive and continue to be explored, discussed and debated via research in multi-disciplinary areas. According to Salikin (2003), a development system is considered to be sustainable if it is ecologically sound, economically valuable and socially just. This view is similar to the ‘triple P’ concept popularized by Munasinahe (1993). The three P's are economic development (profit), social development (people) and ecological/environmental protection (planet) and these dimensions are seen as influencing each other and should be balanced.

This view is also supported by Thrupp (1996) and Buttimer (2001). Thrupp (1996) emphasized that agricultural activities are sustainable if the elements of ecology, economic profitability and social responsibility are integrated. Under this concept, efforts to increase food production from the agricultural sector, for instance, must continuously aim to minimize any potentially deleterious impacts on the environment and quality of life. Such agricultural practices include conserving the soil fertility, minimizing the use of and dependency on non-renewable resources, enhancing rural poor social equity, empowering farmers and creating job opportunities, reducing poverty and famine, ensuring agricultural communities' health and safety as well as sustaining and improving the quality of the environment, biodiversity and natural resources. Similarly, Buttimer (2001) also classified three crucial elements that are vital in promoting sustainable agriculture. These elements are economic growth, social vitality and ecological integrity. Thus, sustainable approaches to agricultural development not only focus on increasing the production scale but also seek to improve social well-being (equal opportunity, open participation in decision making and socially just) and conserve the biodiversity, ecosystem and environmental quality.

Even though most scholars evaluate sustainable development according to three dimensions (economy, ecology and social), Saragih et al. (2007) viewed institutions as another important element in these dimensions. According to Saragih et al. (2007), institutional sustainability is achieved when the existing structures and processes are able to perform their function and contribute positively to society in the long term. The University of the Philippines Los Baños identified five pillars that are important to developing a sustainable agriculture framework (Zamora, 1999). It was defined as a “system of production that makes agriculture economically feasible, ecologically sound, socially just and humane (equitable), culturally appropriate and grounded on holistic (systems and integrative) science” (Zamora, 1995). Nurmalina (2008) adopted five dimensions that comprise the elements of ecology, economy, social, technology and institutions to measure the sustainability index and status of the rice availability system in Indonesia.

Therefore, the term “sustainability” and its approaches remains varied, particularly in agriculture. This reflects the diversity of issues and challenges faced by unique communities in different countries. For instance, Thailand's holistic sustainable development approach is defined based on six dimensions. Apart from economic, social and environmental aspects, other important aspects include politics, knowledge and technology as well as mental and spiritual balance (Dalal-Clayton and Bass, 2002). In this study, five dimensions, which include the aspects of ecology, economy, society, technology and institutions, were measured to analyse the sustainability of paddy farming in the Northern Terengganu Integrated Agricultural Development Area (KETARA). The analysis was performed based on structural equation modelling.

3. Methods and materials

This research was undertaken in the Northern Terengganu Integrated Agricultural Development Area (IADA KETARA). The IADA KETARA is one of the eight granary areas that was designated under the National Agricultural Policy for double cropping paddies through the introduction of high yield varieties, intensive irrigation facilities and adoption of modern farming practices. The area covers the Besut and Setiu Districts; the Besut District has an area of 122,831 ha, and the Setiu District has an area of 139,905 ha. The overall size of this area is 258,736 ha, incorporating 58,000 ha for agriculture and 12,000 ha for paddies. In 2013, the total paddy area in the region was 9752 ha, involving nearly 2700 farmers (Department of Agriculture, 2014).

A sample of 350 farmers who are members of the Water Consumer Group (KPA) in IADA KETARA was randomly selected. The survey was conducted from October to December 2012. The sample size was deemed sufficient, as SEM scholars such as Hair et al. (2010) proposed a sample size of 150–400. In greater detail, the sample number can also be determined based on the samples per parameter, for example, 5 to 10 samples per parameter (Haryono and Wardoyo, 2012) or 15 samples per parameter (Santoso, 2012). In this study, the data were collected based on the stratified random sampling approach using a structured questionnaire. The multivariate analysis techniques are based on a structural equation modelling approach using the AMOS 18 program. Among the analyses performed were explanatory factor analysis, confirmatory factor analysis and goodness of fit tests. As shown in Table 1, the sustainability dimensions in this study cover five variables, which include ecology, economy, society, technology and institutions.

4. Results and discussion

Fig. 1 shows the sustainability model with the constructs and their indicator variables. The model dropped 16 items and maintained 18 valid and reliable indicator items to measure the five constructs. All of the remaining items met the statistical requirements mentioned by Awang (2012), such as a Cronbach's alpha $>.7$, construct reliability (CR) $> .6$ and average variance extracted (AVE) $> .5$. The model also shows an acceptable fit (good

Table 1
The sustainability indicators for paddy farming.

Variables	Indicators	Codes
Economy (8)	Incomes	EKN1
	Off-farm activities	EKN2
	Asset/real estate property	EKN3
	Marketing	EKN4
	Market demand	EKN5
	Debt	EKN6
	Savings	EKN7
	Capital	EKN8
Social (7)	Life status	SOS1
	Social network	SOS2
	Passion for work	SOS3
	Receptivity to changes	SOS4
	Social problems	SOS5
	Size of family	SOS6
	Number of workers	SOS7
Ecology (7)	Weather	EKL1
	Weeds/disease/pests	EKL2
	Production	EKL3
	Soil fertility	EKL4
	Planting schedule	EKL5
	Pollution	EKL6
	Water availability	EKL7
Institutions (5)	Government support	INS1
	NGOs support	INS2
	Financial management	INS3
	Drainage/irrigation management	INS4
	Marketing assistance	INS5
Technology (7)	Environmentally friendly technology	TEK1
	Infrastructure	TEK2
	Fertiliser/pesticide	TEK3
	Training	TEK4
	Machinery	TEK5
	Planning	TEK6
	Technology development	TEK7

Source: authors' illustrations.

fit) from the absolute fit [x^2 (397.501 > .05), RMSEA (.077 < .08)], incremental fit [CFI (.968 > .90), TLI (.962 > .90), NFI (.953 > .90)] and parsimonius fit [Chisq/df (3.081 < 5.0)] values. In addition, based on the Modification Indices (MI) value, the model was further modified to increase the model fit.

The model indicates that the sustainability of paddy farming in IADA KETARA was determined by 48 variables; 18 are observed variables, and the rest are unobserved variables. Out of 48 variables, 24 are exogenous variables, whereas the rest are endogenous variables. According to Santoso (2012), an observed variable is also known as a latent variable, construct or latent construct, where these variables cannot be measured directly, except with one or more unobserved variables. The unobserved variables are variables that explain or measure observed variables, which are also known as manifest variables, measured variables or indicators, whereas exogenous variables (independent variables that influence dependent variables and endogenous variables) are dependent variables that influence the independent variables. The path coefficients in the model were estimated by the regression weights (Table 2).

Based on the estimation values in Table 2, it can be concluded that sustainability (an endogenous latent construct) has a statistically direct influence on EKL, SOS and TEK (exogenous latent construct), as the CR values (t-values) are above 1.96. However, the impact of sustainability on INS was found to be statistically insignificant. Given the EKN's coefficient value of 1, EKN can be considered to be a reference point.

Based on the SRW estimation values, as sustainability increases by one standard deviation (SD), EKL will drop by .597 SD, while EKN, SOS, EKN and TEK will increase by .263 SD, .210 SD, .041 SD and .640 SD, respectively. Given that TEK has a dominant positive influence on sustainability, adoption of technology for sustainable paddy farming systems needs to be enhanced in addition to minimizing the ecological impacts. The Technology (TEK) variables are determined by three indicators, represented by TEK1 (environmentally friendly technology), TEK3 (fertilizers/pesticides) and TEK4 (training), with factor loading of .79, .75 and .99, respectively. Therefore, conducting training to improve knowledge and skills would be the most effective mechanism to promote and cultivate sustainable paddy farming practices among farmers. If they are given an option, farmers prefer to adopt environmentally friendly farming systems over current practices, which heavily rely on fertilizers and pesticides to increase productivity.

The EKN variables that measure the economic aspects are represented by four indicators, EK1 (income), EKN2 (off-farm activities), EKN4 (marketing) and EKN 6 (debt), with loading factors of .85, .99, .66 and 1.00, respectively. It can be concluded that most of the farmers in IADA KETARA are not debt-burdened. Most of them do not like to get into debt, whether for capital expenses or for household expenditures. The introduction of the IADA project in their area has also given them the opportunity to be involved in off-farm activities (EKN2), such as IADA's entrepreneurship program, which aims to help farmers earn extra income. Such programs have proven to be effective given the high value of the ENK1 loading factor. Nonetheless, the low loading factor value for EKN4 implies that the existing marketing programmes still need to be improved. Farmers are complaining about the marketing system, which is monopolized by a single institution.

The social (SOS) aspects are determined by four indicators, SOS1 (life status), SOS4 (receptivity to changes), SOS6 (size of a family) and SOS7 (number of workers), with loading factor values of .93, .97, .96 and .79, respectively. The findings showed that most of the paddy farmers in IADA KETARA are receptive to changes, which is particularly important in relation to technology diffusion and adoption. Achieving sustainable farming behaviours requires the acceptance of farmers to change their social norms (Hallam et al., 2012). In terms of ecology (EKL), both climate variability (EKL1) and soil fertility (EKL4) are the important factors that affect the sustainability of paddy farming. According to Mustapha (1995), government policy intervention and support to promote sustainable agricultural development is crucial, particularly in relation to natural resources and conservation. However, in this study, the INS variable was not found to be significant, even though several indicators of INS, such as INS1 (government support), INS4 (drainage and irrigation management) and INS5 (marketing assistance), are significant. Although the results indicate that INS does not influence sustainability, this study demonstrates that INS could have an indirect impact on sustainability through the effect on EKL, which was not taken into consideration in this study.

5. Conclusion

This study examined the factors that influence the paddy farming sustainability in IADA KETARA based on five constructs: economy (EKN), ecology (EKL), society (SOS), institutions (INS) and technology (TEK). The results from SEM analysis showed that all five constructs can be measured based on multiple indicators. Except for INS, the inter-construct relationship showed that the other four contracts are significant indicators to promote sustainability in paddy farming in the IADA KETARA area. Although INS was not statistically significant, the importance of government support and marketing assistance are deemed to be vital, particularly to create synergy in farmers' responses considering the education level of farmers (low education level).

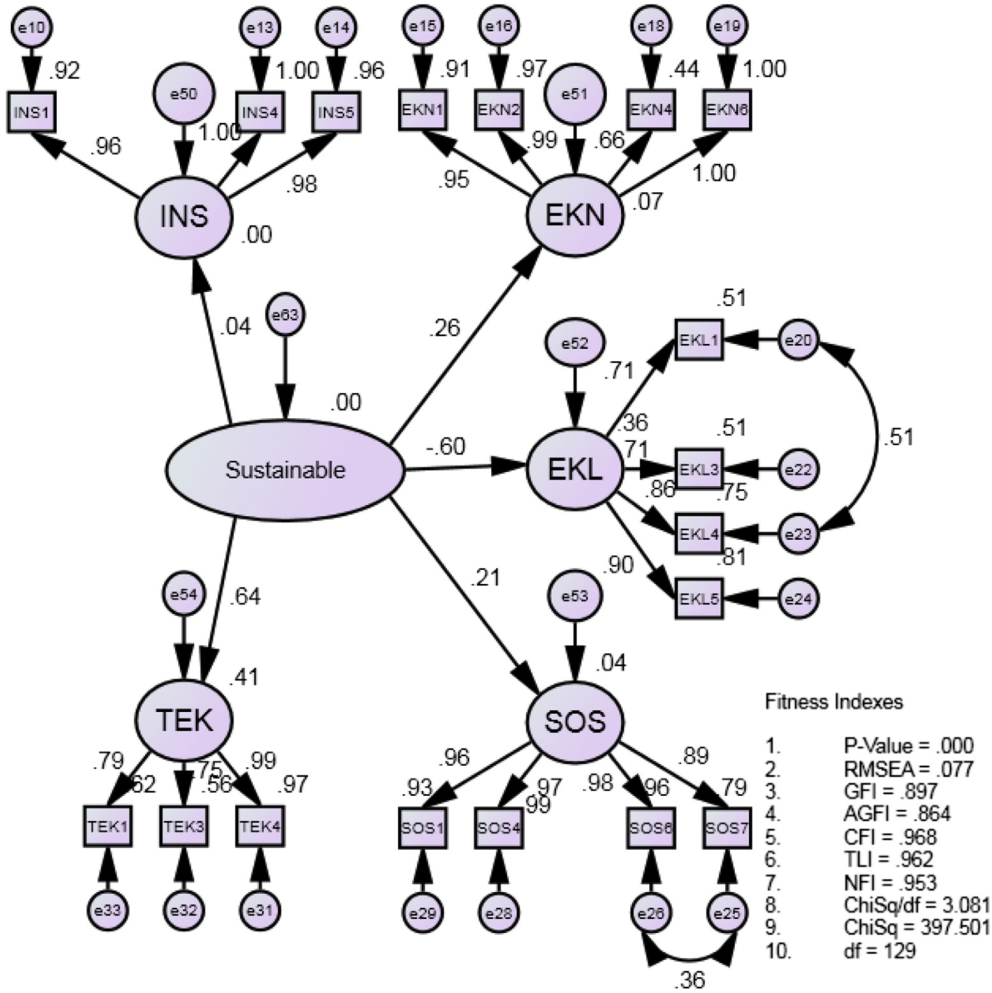

Fig. 1. The sustainability model of paddy farming.
Source: authors' calculation.

Table 2
Estimated regression weights.

Relationship between constructs			Regression weights estimate	Standardized regression weights estimate	S.E.	C.R.	P-value
EKL	<—	Sustainability	−1.238	−.597	.406	−3.052	.021
EKN	<—	Sustainability	1.000	.263	Reference point		
SOS	<—	Sustainability	.695	.210	.283	2.453	.014
INS	<—	Sustainability	.158	.041	.288	.548	.584
TEK	<—	Sustainability	1.536	.640	.545	2.821	.052
INS1	<—	INS	1.000	.959	Reference point		
INS4	<—	INS	1.087	.997	.018	59.879	***
INS5	<—	INS	1.042	.978	.021	50.850	***
EKN1	<—	EKN	1.000	.954	Reference point		
EKN2	<—	EKN	1.021	.987	.019	52.727	***
EKN4	<—	EKN	.668	.664	.042	15.945	***
EKN6	<—	EKN	1.038	.998	.018	58.205	***
EKL1	<—	EKL	1.000	.714	Reference point		
EKL3	<—	EKL	.977	.714	.079	12.350	***
EKL4	<—	EKL	1.315	.864	.065	20.218	***
EKL5	<—	EKL	1.433	.901	.104	13.709	***
SOS7	<—	SOS	1.000	.889	Reference point		
SOS6	<—	SOS	1.191	.981	.031	38.315	***
SOS4	<—	SOS	1.183	.985	.035	33.800	***
SOS1	<—	SOS	1.190	.963	.038	31.406	***
TEK4	<—	TEK	1.000	.987	Reference point		
TEK3	<—	TEK	.643	.751	.038	17.019	***
TEK1	<—	TEK	.795	.785	.044	17.889	***

Notes: S.E. is standard error; C.R. is construct reliability; ***significant at 99%.
Source: authors' calculations.

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